Research FOR FARMERS

SUMMER—1960

CANADA DEPARTMENT OF AGRICULTURE

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CANADA DEPARTMENT OF AGRICULTURE
Ottawa, Ontario

HON. DOUGLAS S. HARKNESS — *Minister*
S. C. BARRY — *Deputy Minister*

NOTES AND COMMENTS

It seems inevitable that more and more attention is being focused on the problems of disease and insect control through the application of chemical and biological materials. As agriculture becomes more specialized and more intensified, the attendant problems of pest control assume increasing importance. Apart from the immediate question of effective protection against damage, the researcher must face the prospect of a gradual build-up of resistance to a once-satisfactory remedy and be ready with an acceptable alternative at the appropriate time. No less important is the matter of harmful residues on crops consumed by animals and humans. It is not enough that a pesticide be effective, it must also be safe. And finally, consideration must be given to the cumulative effect on plants, animals and soil, of repeated applications of pest control products. It is more than coincidence that so much of this issue is taken up with problems of pest control. And the variety of subject matter reflects the many aspects of the matter that are engaging the attention of the Department.

* * *

Application of chemical fertilizers to the soil as a means of stimulating plant growth is commonplace. Increases in size and yield are expected and are usually realized. But the use of chemical substances to produce an opposite effect is rather unusual. Recent experiments involving the use of growth-inhibiting chemicals have produced results of some promise for commercial growers of ornamental pot plants. Some plants tend to become too tall for present-day requirements when produced under optimum growth conditions. Under less favorable conditions, quality suffers. The addition of certain chemicals to the soil has caused a reduction of normal internode elongation, resulting in a shorter, more desirable plant. So far the chemicals appear to be quite selective; one plant responds, another gives no result. Nor is the treatment without its drawbacks. Despite these, however, the idea is a promising one and may eventually place in the hands of the grower one more tool that will help him to regulate his production to the precise needs of his market.

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Vol. 5 No. 3

"*Research for Farmers*" is published quarterly by the Canada Department of Agriculture. Its purpose is to help keep extension workers informed of developments in research and experimentation as carried on by the various units of the Department.

Contributions should be addressed to the Secretary, Editorial Board, Information Division, Canada Department of Agriculture, Ottawa.

Cover Photo—The Canadian producer, in addition to meeting domestic spray regulations, must now also keep foreign requirements in mind in selecting pest control materials and practices.
(See story, page 7.)

Leaf in upper left-hand corner is typical of Dollard 'no mark' type, while rest are representative of the Ottawa 'marked' type.

Environment

Changes Lasalle Red Clover

J. E. R. Greenshields

THE problem of maintaining varieties of forage crops that perform consistently over long periods is of concern to both the scientist and the farmer. Unlike many other crops, forage species are mostly perennial or biennial in growth habit. This means that they are often exposed to many hard cold winters with conditions varying from deep snow to icing or severe cold without any snow. Moreover, with a few exceptions they are cross-pollinated by wind or insects and regardless of how careful a seed grower may be, some contamination will take place.

Because of good general performance, many varieties are grown over a wide area. While the summers in the different regions may be similar, the winters are often very different, and the variety must remain stable under this "double standard". Examples of varieties that have changed greatly due to being grown in different regions of the U.S.A. and Canada are Grimm and Ladak alfalfa. The same variety obtained from widely separated regions often performs quite differently.

Lasalle red clover is probably the best example of a variety that has changed as a result of being grown in different places. Lasalle was made up by mixing Foundation seed of the varieties Ottawa and Dollard on a 50-50 basis. Although Ottawa and Dollard look alike in most respects, they differ in one visible characteristic. Nearly all the plants of Ottawa have a mark on the center of the leaflet, while very few plants of Dollard have this mark. Apart from distinguishing the two varieties, the mark has no significance.

When Lasalle was released in 1952 it was placed under the Canadian Forage Seeds Project, and seed growers in both Eastern and Western Canada produced seed of it. If Dollard and Ottawa had remained in the mixture in the same proportion in the Approved, Registered and Certified generations, 70 per cent of the plants should have the leaf mark, and 30 per cent no mark.

To determine the stability of Lasalle seed from the "control samples" of 32 farmers was obtained, and plants were grown to see whether either the Dollard or Ottawa parental variety was gaining the advantage. The results are given in the table below.

In each instance these seed lots originated from the same Foundation "Lasalle", but one can see at a glance that the results are quite different. In Eastern Canada (Ontario to the Maritimes), the leaf mark remains at about 70 per cent 'marked' to 30 per cent 'no mark', while in Western Canada (Alberta, Saskatchewan and Manitoba) there is a definite increase in the proportion of the non-marked Dollard parent. The trend continued, and after three generations in the West the crop showed only 36 per cent 'marked' plants. In the East however, there is a slight shift toward the 'mark' in some of the seed lots. This situation may indicate the presence of some volunteers or some outcrossing, because in all sources of contamination it is difficult to find a plant without the mark.

There may be a number of reasons for this shift to the Dollard type. Ottawa may be less hardy than Dollard in the West or the fact that Ottawa is a few days earlier may cause it to miss the best pollinating period. This difference in flowering time is increased in the West because a single-cut system is used, whereas in the East, on the second cut, which is used for seed, flowering time of the two varieties almost coincides.

In Canada we have always been very careful about outside contamination of our seed by strict enforcement of our Seeds' Act Regulations, but these results indicate that we may have to be careful in other respects where detection and control are not so easy. Although we cannot demonstrate it so readily, other varieties of legumes and grasses may be changing in each generation even more than Lasalle. For example, much Rambler alfalfa seed is being produced in California and shipped back to Canada. While we need the seed, results such as those on Lasalle would indicate that there is a good sound basis for restricting the number of generations that pedigreed seed may be grown outside its area of adaptation.

Leaf Mark Distribution in Seed Lots of Lasalle Red Clover in Relation to Area of Seed Production

Status of seed tested	Region where grown	No. of generations in the region	% leaves marked	% leaves with no mark
Approved	East	1	76	24
Approved	West	1	62	38
Registered	East	2	71	29
Registered	West	2	43	57
Certified	East	3	80	20
Certified	West	3	36	64

Dr. Greenshields is a forage crops specialist with the Genetics and Plant Breeding Research Institute, Ottawa.

Onion maggot damage; plant at right was grown from transplanted seedling and shows typical symptoms of maggot damage.

Control of the Onion Maggot in B.C.

D. G. Finlayson

THE battle is on again! The onion maggot, which seemed to yield so readily to applications of the chlorinated hydrocarbon type of insecticides, has developed strains resistant to aldrin, dieldrin, heptachlor, and chlordane in the onion-growing districts of British Columbia.

Recent experiments initiated by the Kamloops Laboratory were designed primarily to develop a control method for onions grown from seed. All treatments gave effective and comparable control under a medium infestation. Chlordane as a furrow treatment damaged the plants; oil emulsions and lindane as soil drenches were costly to apply; calomel and DDT as seed treatments were comparable in effectiveness but calomel was some four times more expensive. One draw-back was experienced with the DDT seed-treatment: so much insecticide was necessary that it did not stick well to the seed, and the treated seed would not flow evenly through the seeder.

We tested other chlorinated hydrocarbon insecticides in comparison with DDT and with calomel and proved that seed treatments with BHC, aldrin and dieldrin would control onion maggot as effectively as DDT using only ⅛ to 1/16 the amount of insecticide. However, these and previous trials indicated that all except dieldrin were causing reductions in percentage germination and abnormal plant growth.

In addition to the tests on onions grown from seed, experiments were undertaken to develop control methods for maggots in onions grown from transplants. Three methods of application were investigated: (1) surface applications, (2) furrow treatments and (3) treatments in which the bulbs and seedlings were dipped in

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The author is a root maggot specialist with the Entomology Laboratory, Kamloops, B.C.

Onion maggot control. *Left:* Onions from seed treated with (left to right) endrin, malathion, dieldrin, heptachlor, and untreated. *Right:* Transplanted seedlings destroyed even though treated with heptachlor and dieldrin.

slurries or emulsions immediately before planting. Furrow treatments were preferred since the insecticides were concentrated at the point of attack of the maggots, namely, the stem base-root area of the onion. Dipping the transplants in emulsions and slurries, although giving protection, caused severe phytotoxicity.

Since field observations indicated that some insecticides were interfering with plant growth and possibly preventing germination, we conducted controlled experiments and demonstrated, under optimum conditions, that germination of the seed was normal, but that most of the chlorinated hydrocarbon insecticides when used at excessive rates caused abnormal growth. Further, lindane and some formulations of aldrin, when used at rates necessary for control often killed the plants.

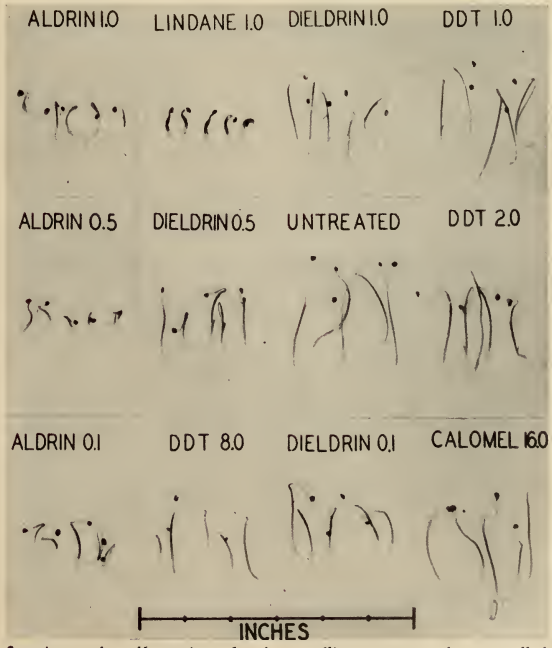
In 1955 conflicting reports of onion maggot damage in treated fields of onions in northwestern United States led to co-operative onion maggot control experiments in Idaho, Oregon, Washington and British Columbia. In 1955 and 1956 these experiments showed that strains of onion maggots resistant to some of the chlorinated hydrocarbon insecticides were present in all areas but British Columbia. They also suggested that soil types or climate or both had a marked effect on the efficiency of some insecticides. Similar experiments conducted in various onion growing districts in Canada confirmed the British Columbia findings that no resistant strains were present at that time.

Experiments to investigate the effectiveness of the insecticides in various soils were conducted at Kamloops from 1957 to 1959. Soils from various localities in the Pacific Northwest were shipped to Kamloops for assessing maggot damage under uniform conditions and by one strain of flies. The seed, untreated and treated with heptachlor, dieldrin, endrin, and malathion at 1 oz. of toxicant per pound of seed, was sown in various soil types in flats countersunk to the level of the onion field. Thus the onions were exposed to a natural infestation from the time of emergence until harvest. The treatments had little or no effect on seedling emergence nor were other phytotoxic symptoms noted. The three chlorinated hydrocarbon insecticides gave good control of the onion maggot in all soil types during the first year; malathion did not. The treatments and checks had a higher percentage damage in peat and muck than in mineral soils.

In 1958 data from these experiments suggested that the strain of flies at the Laboratory farm was developing resistance to the chlorinated hydrocarbon insecticides, especially heptachlor and dieldrin. Reports from other districts in British Columbia suggested that the condition was not confined to Kamloops. Further reports from Ontario and to a lesser degree Quebec indicated that strains of resistant flies were general across Canada and the United States.

Experiments conducted in British Columbia, Ontario and Quebec in 1959 following preliminary investigations with some of the phosphate insecticides showed that Trithion, Ethion and Diazanon used by various methods would effectively control the strain of resistant maggots. Although Diazanon proved an effective insecticide in onion maggot control, caution had to be exercised because several formulations caused damage to the plants.

We are continuing our researches on the effectiveness of organophosphates in various soil types to determine the optimum rates and formulations and the best methods of application. Experiments are to be conducted on the timing of topical applications of DDT and other insecticides to control flies. In addition, a careful study on the degree of resistance to various insecticides will be made with a view to altering recommendations often enough to possibly prevent the development of resistant strains. Also, we will continue our studies on the phytotoxic effects of the various insecticides to determine not only what insecticides cause abnormalities but how. In conjunction with the latter, residue studies are to be undertaken.



Stunting and malformation of onion seedlings grown under controlled conditions (75 deg. F. and 70 per cent relative humidity) from seed treated with insecticides at various rates (ounces per pound of seed).

Enemy of Chickens and Turkeys . . .

Chronic Respiratory Disease (CRD)

S. E. Magwood AND G. L. Bannister

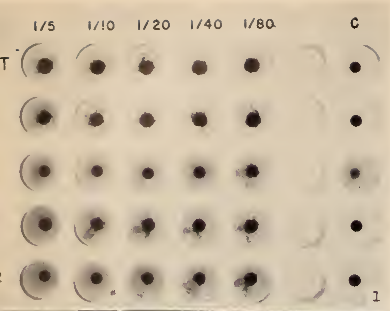


Fig. 1: PPLO—Heamaglutination (HI) test.

Fig. 2: Air sacs dissected out; normal (upper), diseased (lower).

Fig. 3: Tracheas, normal (lower) and diseased (upper).

Fig. 4: Normal and diseased air sacs in one bird. A, normal; B, diseased.

CHRONIC Respiratory Disease (CRD) is now the most important respiratory disease of chickens and turkeys in Canada. It is believed to be caused by the pleuropneumonia-like organism (PPLO), *Mycoplasma gallinarium,* but the clinical disease is commonly aggravated by secondary bacterial invaders. Since apparently healthy birds frequently harbor PPLO, stress-inducing conditions such as vaccination against other respiratory diseases, chilling, and poor ventilation, frequently "trigger off" an outbreak. Thus if vaccination is contemplated, the advice of a poultry pathologist who is familiar with the status of the diseases in the area should be sought.

Early symptoms are nasal discharge, conjunctivitis, respiratory rales, "snicking" sounds and coughing, followed by loss of appetite, loss of weight and, in laying birds, lowered egg production. Pathological changes found on post-mortem examination include thickening of the walls of the air sacs with production of a cheesy exudate; the sinuses of turkeys are frequently distended with clear syrupy fluid. Infection in the air sacs may extend to other organs and frequently produces pericarditis and perihepatitis.

The authors are in charge of the Poultry Pathology and Virology Units respectively at the Animal Diseases Research Institute, Hull, Quebec.

The PPLO is transmitted through the egg to the chick. The rearing of PPLO-free chicks is dependent upon the parent flock being free of the bacteria or, in the cases of PPLO infected flocks, breaking this transmission cycle by antibiotic injections.

The absence of PPLO can be determined on a *flock basis* by serological tests. One type of test used routinely in the Animal Diseases Research Institute is shown in Figure 1. This test makes use of the principle that the organisms have the property of causing clumping of chicken red blood cells as shown by the antigen titration (Tit) and the negative serum (N). Antibodies in infected birds'

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Apparently healthy birds frequently harbor PPLO.

Food Safety and Pesticide Use

H. Hurtig

PEST CONTROL through the use of chemicals has evolved from an art to a complex technology. The technology is based on information produced by scientific research. Gaps in our knowledge today have created uncertainties about the continued use of currently accepted pesticides and have forced a more critical approach to the introduction of new chemicals. Health authorities and agricultural research and extension agencies must form a smooth working partnership in order to avoid confusion for the grower.

Because of the alarmist publicity that has accompanied the correction of rare abuses of these valuable tools in production, the consumer is now as concerned about the safety of the food supply as he is about quality and price. Existing controls of residues employ large safety factors where the hazard is defined, and even larger safety factors where there is room for doubt. This is reflected by the zero tolerances which now prevail for many pesticide residues in human foods. The existing gaps in scientific knowledge strongly affect the philosophies of approach to the control of pesticide use, resulting in a policy of erring on the side of safety. The chemical industry and agricultural research and extension workers will continue to play a basic role in making new developments available for general use, but final responsibility for correct use lies with the farmer. If the events of the past year are any indication, the next few years will see further uncertainties arise regarding the status of some chemicals now used in food production. Extremely good team work and liaison is now required between research and extension specialists and the farmer. In order to promote this liaison the Research Branch has a Pesticide Technical Information Office in Ottawa.

Dr. Hurtig is Associate Director (Pesticides), Program Directorate, Research Branch, Ottawa.

In Canada the Food and Drug Directorate of the Department of National Health and Welfare establishes the legal limits of pesticide residues that may remain in human food; the Department of Agriculture is concerned with ensuring that pesticides are used in a *safe, efficient* and *economical* fashion. The registration and regulation of the sale of pesticides under the Pest Control Products Act is the responsibility of the Production and Marketing Branch. Consultation between the Food and Drug Directorate, Production and Marketing Branch, and the Research Branch ensure that the manufacturers' claims for performance are valid and that the instructions for use, precautions to be observed etc. are such that the residue tolerance requirements of the Food and Drugs Act can be met by following the instructions on the label. The Research Branch not only acts as an advisor and consultant to the administrators of the Pest Control Products Act, but also carries a fluid program of research, testing and development of national and regional scope aimed at adapting the use of new chemicals to the special requirements of Canadian agriculture. Data developed by the manufacturer in the U.S.A. or other countries go a long way toward meeting our requirements, but they are not always applicable to Canadian conditions of use. For example, in the U.S.A. the Food and Drug Administration establishes residue tolerances on animal feeds. In Canada the Food and Drugs Act provides residue tolerances for human food only. Therefore we must ensure that recommendations for the use of pesticides that might end up in forage, cannery wastes, or other animal feeds, are such that the final animal product is free of illegal residues.

In 1959, as the results were analyzed for three years of research on the stability of some of the cyclodiene compounds and data evaluated on the potential for accumulation of residues in animal products, it was deemed necessary to withdraw recommendations for the use of aldrin, dieldrin, chlor-

Author (left) discussing petitions to establish residue tolerances and precautionary labelling requirements with Dr. R. A. Chapman (center), Food and Drug Directorate, Dept. of National Health & Welfare, and C. H. Jefferson, Feed, Fertilizer and Pesticide Section, Canada Dept. of Agriculture.

dane, heptachlor and toxaphene on forage in order to maintain the residue-free status of animal products. These compounds have been very valuable, especially as grasshopper control agents. Current research in the chemical control of grasshoppers on forage crops will emphasize the requirement of freedom from obnoxious residues, and new compounds will be evaluated with this in mind. Also, it was found that heptachlor is converted on plants and in soil to its very stable epoxide. This has necessitated revision of the 1960 recommendations involving the use of heptachlor on vegetables and the deletion of recommendations for its use on certain root crops until further information is available. The various factors affecting rate of heptachlor epoxide formation are not clearly understood and this information must be obtained.

A new development that is attracting interest in the animal production field is the possibility of warble fly and louse control by systemic organophosphate compounds, that may be administered to farm animals as sprays, feed additives, boluses or injections. Compounds now available should be considered as the forerunners of the ideal treatments still to be discovered, since the economic benefits and side effects of their use must be carefully weighed and a number of precautions must be observed. For the present, their use must be restricted to beef animals or other non-lactating animals in order to avoid residue problems in milk. The temptation confronting the farmer raising both beef and dairy animals may be more than he can resist. In this and other cases, instructions on the label should be followed to the letter.

L. A. O. Roadhouse, (left) of Department's Pesticide Technical Information Office, and A. B. Swackhamer, Dept. of National Health & Welfare, discussing spray calendar recommendations and how residue tolerances may be met.

Other countries have been interested in these matters and in the past three years there has been intensified activity in Europe on legislative and other methods of regulating pesticide use and residue tolerances. This is of great importance to Canada since our future ability to export agricultural products is involved. There are already a few differences in legal residue tolerances between countries. For example, in Canada the legal limit for arsenic residues on apples is 2.0 parts per million, in England it is 1.0 p.p.m. Apple growers in the Maritimes and Quebec hoping to export to England must adjust their spray schedules so that the timing of sprays involving lead arsenate is early enough to allow an adequate interval for arsenic residues to degrade to the proper level. A three-year research program has just been concluded which will allow the adjustment of spray schedules to meet these requirements. Further research is still in progress to determine how modern apple scab control fungicides and spray adjuvants affect the persistence of the arsenicals. There is little hope that international tolerances for residues will be developed within the next few years, since existing differences in scientific opinion on how to calculate hazard, national differences in eating habits, pest control problems, agricultural practices, and public opinions play an important role in this matter. Therefore, the Canadian producer must now also keep foreign requirements in mind in selecting pest control materials and practices.

Chronic Respiratory Disease . . . *(from page 6)*

sera will prevent this clumping as illustrated by the positive serum (P). S1 and S2 are typical of sera submitted for diagnosis. This test has been widely used in some parts of Canada in a PPLO control program.

The use of PPLO-free flocks is the most reliable method of securing PPLO-free chicks, but it is a very exacting method in that any additions to any part of the operation must be from PPLO-free flocks. The treatment of infected breeder flocks by injections of a mixture of streptomycin and dihydrostreptomycin to prevent transmission through the egg has been widely practiced. Eggs may be collected for a 10-14 day period after an injection; the eggs are believed to be free of PPLO in this period. In some areas the method has enabled the establishment of PPLO-free flocks but it has not been uniformly successful.

When the laboratory diagnosis has confirmed the presence of PPLO as the principal agent in an outbreak of respiratory disease the course of action to be followed will depend on the potential value of the flock. Improvement in the environment is always essential. Attention should be given to ventilation, possible crowding, sanitation and nutrition. In the case of broiler and production flocks oral medication with antibiotic may be helpful only by improving the appetite. Antibiotic medication of flocks of average value may often be uneconomical, but good nursing will minimize the financial loss. Valuable breeding flocks may be given more prolonged antibiotic medication and the injection of antibiotics might be considered.

Above: **Wheat stem rust: susceptible variety (left) and resistant variety (right).** ***Right:*** **Rusted wheat leaves: untreated (left) and those treated with eradicant chemicals (right).**

Nickel Salts Show Promise
in Grain Rust Control

W. E. Sackston

> **EDITOR'S NOTE**
> *Although the accompanying article was written by Dr. Sackston, it is based on the work of his associates, Dr. Frank Forsyth, now at the Pesticide Research Institute, London, Ontario, and Dr. Bjorn Peturson, recently superannuated from the Research Station at Winnipeg.*

THE most effective way to control grain rust is to sow rust-resistant varieties. Grain farmers in Manitoba and eastern Saskatchewan, the "rust area" of Canada, have been doing just that since 1936. New races of rusts that can attack our resistant varieties sometimes occur in nature, become widespread, and put the farmers back in trouble.

It takes about ten years to produce a new variety of wheat. Of the thousands of potential varieties produced by plant breeders perhaps only one or two will pass all the critical tests required before they can be released to farmers. The time lag between the widespread occurrence of dangerous new rust races, and the release of new varieties resistant to them, was remarkably short in the case of 15 B and Selkirk. This was exceptional and we may not always be so fortunate.

Dr. Sackston is Head, Plant Pathology Laboratory, Canada Department of Agriculture Research Station, Winnipeg, Man.

To meet this challenge, pathologists in many areas have been experimenting with chemicals to control rust, either by preventing infection, or by eradicating rust after it becomes established. Some effective chemicals have been found, but all have had drawbacks. Protectants wash off, and may have to be applied repeatedly, making the process a costly one. Also, to be effective, they must be applied before the rust infection starts—and farmers are unwilling to apply chemicals to control a disease that may not be severe in a given season. Rust infection is not heavy every year: it may be light for years, and then suddenly be disastrous. More attractive than the use of protectant chemicals is the use of eradicants. These need not be applied unless rust infection warrants their use. The chief difficulty in using them is one of logistics—having sufficiently large supplies of chemicals available at distribution points where farmers can get them, on short notice, to apply to millions of acres of grain. The quantities involved are tremendous, and the money tied up in stocks, which may not be needed for years and which may deteriorate, is correspondingly great. No agency, public or private, would willingly undertake such an expense.

Recent researches at the Canada Department of Agriculture Research Laboratory at Winnipeg may help to solve some of the logistics problems. In 1956, Drs. F. R. Forsyth and B. Peturson, working with chemicals supplied under code numbers by chemical company specialists, found several that were effective both as protectants and eradicants against

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Honeybee Diseases Respond to Drugs

But reliance on drugs alone is not sufficient— unless proper sanitary precautions are taken in handling bees and equipment.

H. Katznelson

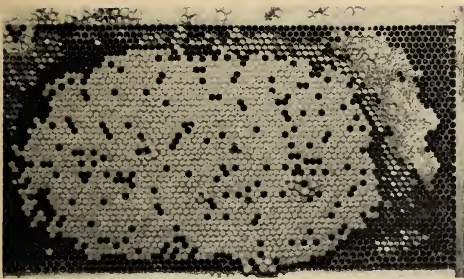
THE honeybee is susceptible to a variety of maladies in both larval and adult forms. Viruses, bacteria, fungi, protozoa and even other insects may cause disease resulting in extensive damage to the colony and eventually to the apiary. One of these diseases is so severe and difficult to control that apiary inspectors are empowered to burn the hive and its contents to eradicate the infection. This drastic treatment and other laborious and time-consuming methods such as fumigation or dipping of hive equipment in boiling solutions of caustic soda led apiculturists to search for simpler means of control. In this quest they found powerful allies in the medical and veterinary professions, for with the start of World War II there began an intensive search for new cures for the many infections and pestilences that accompany and are the aftermath of war. The result of this effort was the development of the antibiotics penicillin, streptomycin, aureomycin, terramycin and a host of others. It was therefore quite natural for enterprising practical apiculturists throughout the world to become interested in these drugs for controlling diseases of the honeybee.

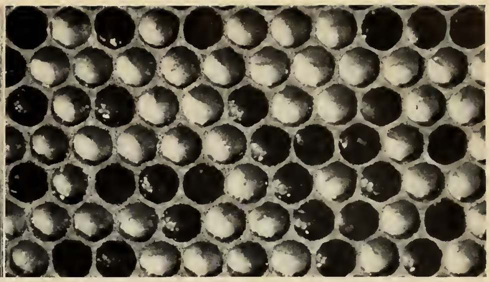
Prior to the advent of the antibiotics, Haseman and Childers of Missouri in 1944 used sulpha drugs effectively against American foulbrood (AFB), the most serious of the bacterial diseases of bee larvae. These drugs when fed in amounts of 500 mg. (1/50 of an ounce) per gallon of syrup to a colony prevented completely the development of AFB naturally or artificially introduced into the hive. One treatment was sufficient to protect a colony for the entire season. Sulphathiazole, sulphaguanidine, sulphadiazine and similar compounds were more or less equally effective. The advantages of these drugs over other substances are their ready availability, their cheapness and their great stability in honey for long periods of time. An experiment completed a few years ago at the Central Experimental Farm showed that honey containing sulphadiazine retained its ability to control AFB for at least three years. One disadvantage of these drugs is their ineffectiveness against any other bacterial diseases of the bee.

Attempts to use antibiotics were begun shortly after 1944 when they became available in quantity. A significant portion of this work has been done by the Canada Department of Agriculture at Ottawa. The three bee diseases most amenable to antibiotic treatment are two bacterial infections of the larvae and a protozoan disease of the adult.

American foulbrood (AFB) is caused by a spore-forming organism *Bacillus larvae*. Because it produces spores this bacterium is difficult to eradicate and since one infected larva contains between one and two billion spores, the disease is readily spread to other larvae. If not checked in time it will destroy the colony. Since the bees try to remove the dead larvae, they contaminate the apiary and then other colonies become infected. Many laborious methods have been developed to eradicate the disease, from fumigating the hives to burning them completely. The use of sulpha drugs was therefore greeted with enthusiasm by beekeepers as a simple, effective treatment. Antibiotics, on the other hand, were found to be rather unstable and therefore not reliable. We have found, for example, that penicillin at a dilution of one part in 5,000,000 completely inhibited *Bacillus larvae* in the laboratory but was ineffective in the apiary; even aureomycin, effective at 1 part in 100,000,000 in the laboratory was not satisfactory. However, terramycin (among other more recently discovered antibiotics) when fed to a colony at the rate of 250 mg. per gallon syrup completely controlled AFB for an entire season. Streptomycin is also quite effective and of the antibiotics tested in our laboratory the most stable.

Dr. Katznelson is Director of the Microbiology Research Institute, Research Branch, Ottawa.





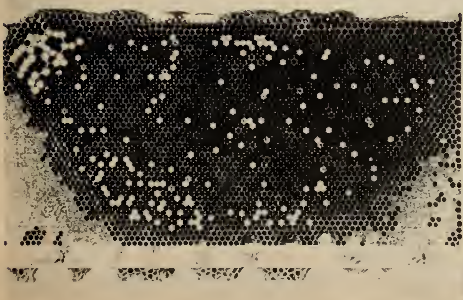
Left: **Normal comb of the honeybee with capped brood, showing uniform brood production.** ***Right:*** **Normal larvae at different stages of development; the pearly white color as well as the glistening surface is characteristic of healthy larvae.**

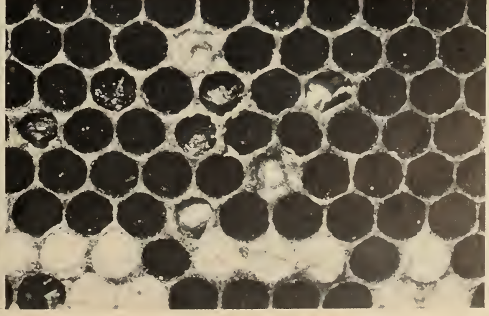
European foulbrood (EFB) is also a bacterial disease of larvae, usually attacking in the spring. There is still controversy as to the kind of bacterium causing this disease but since it is not a spore-former it is not quite so difficult to control as AFB. Streptomycin, aureomycin, terramycin and other substances are effective when fed to or sprayed into colonies, the last of these being perhaps the most effective. It is noteworthy that this material is also the most active against AFB and is therefore a very useful dual-purpose compound. Other antibiotics are being tested currently at various Department of Agriculture stations in Canada.

Nosema disease of the adult bee is caused by a microscopic animal parasite, *Nosema apis*. It is widespread and particularly serious in the spring at which time it reduces the brood-rearing capacity of the colony resulting ultimately in a marked reduction in productivity. Manipulation procedures and fumigation are standard methods of treatment and again apiculturists have turned to drugs as a simpler means of control. Sulpha drugs, arsenicals and the common antibiotics have all been tried in vain in our laboratories and in others throughout the world. However, in 1952 we found that the antibiotic fumagillin in amounts of 1 part in 30,000 reduced infection markedly. Since this first report was published, this substance has been used extensively with considerable success in various parts of the world. Unfortunately fumagillin is not stable and is somewhat toxic, consequently the search for newer and better substances is still going on. Most recently a new compound, Humatin, has been tested in our laboratory, in collaboration with the Apiculture section of the Entomology Research Institute in Ottawa. Against infected bees in cages it appears to be very promising in addition to being stable, soluble and non-toxic. The compound has not been tried in the apiary as yet but plans are underway to do this as soon as possible.

The search for newer and better antibiotics and other drugs to combat bee diseases will undoubtedly go on. However, it is important at this point to sound a word of warning. Reliance on drugs alone to alleviate the ills of the bee is not sufficient. To its sorrow, the medical profession has learned this also with respect to human diseases. Every care should be exercised to prevent the spread of infection to other hives by contaminated tools, extractors, hive equipment and by the beekeeper himself. He must not be lulled into a feeling of false security because he has at hand a means of control. There are too many reports of recurrences of disease where the treatment has been applied improperly or at the wrong time (as during the honey flow). By taking proper sanitary precautions therefore and by exercising intelligent care in handling his bees and equipment the beekeeper may indeed find these drugs the panacea for which he has been searching.

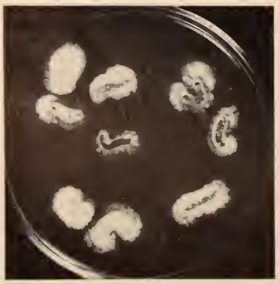
Lower left: **Comb from a colony infected with American foulbrood (AFB); most of brood has been killed and attempts by bees to remove remains of dead larvae by piercing capping on cells may be noted.** ***Lower right:*** **Enlarged section of infected comb, showing dark, decomposing larvae and torn cell cappings.**





Naturally infected larvae of the forest tent caterpillar destroyed by an *Empusa* species.

Upper section of a pea plant showing a cluster of aphids destroyed by *E. aphidis*.



A number of European spruce budworms infected with *B. bassiana;* specimens were surface sterilized in Javex and placed on artificial medium in a sterilized petri plate.

The Role of Fungi in Pest Control

D. M. MacLeod

PARASITIC fungi are generally considered as agents of plant diseases. However, as pathogens of man and animals they may be of greater importance than hitherto supposed, for the effects of those already known are impressive. The forms specifically attacking insects have been under investigation at the Insect Pathology Research Institute at Sault Ste. Marie, Ont., for a number of years.

Some insect-infecting fungi, like the Laboulbeniales which often develop on adult beetles, flies, and cockroaches, are aggressive only to the extent that they are able to colonize and assimilate nutrients from their hosts. They cannot be considered a pathogenic since this relationship does not result in the death of the insect. Another remarkable group, the genus Septobasidium, live in a mutualistic association with colonies of scale insects, using some individuals for food and giving shelter and protection to others. The *pathogenic* forms, of which the genera *Beauveria, Isaria, Hirsutella* and *Empusa* are examples, destroy the host internally. They permeate the body, block the blood circulation, and finally dissolve and break down all the soft parts of the insect. With *Beauveria* and similar forms the insect's cuticle remains more or less intact and becomes packed with closely interwoven hyphae to form a pseudosclerotium or "mummy".

Beauveria species appear to be a constant factor in the natural control of many insect species. Strains of *B. bassiana* have been found on 63 different insect species collected in various localities throughout Canada. Experiments show that the incidence of disease can be increased among insects that hibernate in the soil, by spraying the ground with disease inoculum just before the larval population drops to form cocoons.

Representatives of *Isaria, Hirsutella,* and other closely related genera have recently been isolated from various insects including white grub, brown-shelled scale, codling moth, and spruce budworm larvae. A characteristic of this group (Stilbacease) is, that upon the mummification of the host, they continue to develop from the insect cadaver as "stalk-like" outgrowths of varying length.

The literature records that under favorable conditions, epizootics caused by *Empusa* species have reduced large and destructive outbreaks of insect pests in various countries throughout the world. In Canada, they occur on a wide range of insect species from a number of orders, of which members of the Lepidoptera seem to be the most susceptible. Two species, *E. grylli* and *E.* (*Entomophthora*) *sphaerosperma,* have been reported on the spruce budworm; the former is the more prevalent and has occurred on larvae in British Columbia, Ontario, and New Brunswick. The latter species has been confined to larvae from British Columbia and Alberta. Both species also develop on the Eastern hemlock looper, but in this case *E. sphaerosperma* is more important. In apple orchards in the Annapolis Valley, Nova Scotia, where *E. sphaerosperma* is present, nymphs of the European apple sucker are frequently so reduced in numbers that they cause very little injury to the trees. The green apple bug, another apple pest, which in the past has done a great deal of damage in the Annapolis Valley, has been practically held in check by *E. erupta*. A strain of *E. muscae*, the house-fly pathogen, is frequently isolated from infected onion-maggot flies. It has been shown that *E. aphidis* is capable of destroying heavy infesta-

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tions of pea aphids. Indeed, *Empusa* species are regarded as the most important known pathogens of aphids; at least 10 are known to attack these insects, and recently an additional four, isolated from the spotted alfalfa aphid, have been named and described at the University of California. These new species were artificially disseminated in fields infested with disease-free insects, with subsequent marked reduction in the aphid populations. Another *Empusa* species is important in the natural control of the forest tent caterpillar. This fungus caused high larval mortality at widely separated points in Ontario from 1949 to 1952. In one area, 150 dead larvae were counted on one square foot of bark surface near the base of one of the trees examined. Still another *Empusa* species is the most important fungal pathogen among feeding larvae of the larch sawfly and some localized populations are known to have suffered heavy mortality.

A remarkable characteristic of some significance with *Empusa* pathogens is their particularly effective means of dissemination. In nature, infection of the host results when a germ tube from an airborne spore or conidium penetrates the outer covering of the insect and enters the body cavity. In the host the fungus does not develop in the form of mycelial threads, as do the majority of entomogenous forms, but by a peculiar budding process in which so-called hyphal bodies are formed. These, in the final stages of infection, give rise to large club-shaped structures called conidiophores that penetrate the outer covering of the host and form cònidia on the surface. When the conidia are mature, they are violently discharged into the air in all directions, the cast off spores forming an aureole around the infected insect. In this way, numbers of healthy insects may be infected from one dead individual in their midst. Moreover, each spore as it is thrown off carries with it a portion of the contents of the cell upon which it was borne; this is a sticky substance that enables the spore to adhere to any object against which it happens to strike.

Besides the type of "air spore" or conidium just described, some species of fungi under certain conditions may produce another type, generally formed within the body of the insect and known as "resting spores". Such spores have thick, tripled-layered walls and are believed to afford the fungus a means of hibernation or a way of withstanding adverse conditions. A single season is thought to be the normal period of this resting state, but it may extend over more than one season.

Although insect pathogens do not always develop at the same rate in their respective host, as a rule the death of the insect occurs before the fruiting stage of the fungus is reached; not so, however, with *E. erupta* on the green apple bug. In observing infected nymphs or adults for the first time, one is always amazed to find that even when greatly mutilated some specimens are still able to move over the foliage quite freely and at a surprisingly rapid rate. This continued ability to move is of great importance in the spread of the disease since the conidia are discharged as the insect wanders over the trees, thus distributing the spores in a far more efficient manner than would otherwise be possible.

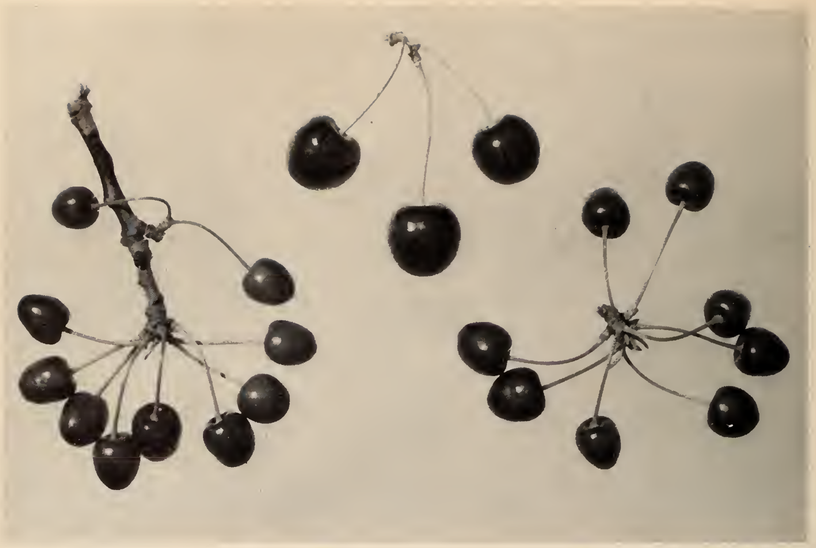
An apparent adjunct to pathogenicity is the possible toxicity of the pathogen. In the spring, 1959, issue of "Research for Farmers" it was reported that a crystalloid parasporal inclusion that develops in the vegetative rod of the bacterium *Bacillus thuringiensis* is composed of a substance that is toxic to the larvae of many insects. The germinating spores of *Beauveria bassiana* have also been reported to produce a substance that acts as a contact toxin when used against certain insects. While this has not been confirmed, there are, nevertheless, indications that fungi attacking insects secrete biologically active compounds; as shown by the actual penetration of the pathogen through the outer integument, and its complete digestion of the softer insect tissue. It is conceivable that some of the secretions may be toxic. Moreover, it is known that toxic chemicals are formed by some of the more important plant pathogens.

The mycelium, or vegetative growth, of a fungus usually consists of fine threads; these, together with some "air spores", are rather sensitive to desiccation. Economic control of insects by entomogenous fungi is, therefore, most effective in areas with wet weather or high humidity; elsewhere, their activities tend to be too temporary. Nevertheless, as indicated above, there is ample evidence to show that these organisms are highly beneficial in the control of insects in the various forest and farming regions of Canada.

Although the influence of environmental conditions is important, the effective use of these pathogens is dependent on our ability to obtain pure cultures of such organisms on artificial media. A large number of fungi are very easy to grow in the laboratory but many of the pathogenic organisms have very specific requirements and have not yet been successfully cultured. *Empusa* species have been especially difficult to grow, but in Germany a medium has been developed recently for the growth

(*Concluded on page 16*)

A mummified white-grub, displaying 'stalk-like' outgrowths characteristic of certain genera of pathogenic fungi.



Fruit symptoms of little-cherry disease. Normal fruits (center) from an uninfected sweet cherry tree; the small red fruits are from an infected tree inoculated with buds from a flowering cherry tree.

What Do We Know About Little-Cherry Disease?

Virus lurking in ornamental flowering cherries found to be cause of outbreak that virtually wiped out commercial cherry growing in the B.C. Kootenays

J. M. Wilks

WHEN new virus disease outbreaks occur, usually the reasons for their sudden appearance are obscure. This was true until recently of the little-cherry disease that was first reported in British Columbia in 1933 from a single orchard near Nelson. By 1948 the disease had spread throughout the West Kootenay region and Creston Valley, infecting every orchard. The only commercial cherry plantings that remain unaffected today are in two isolated districts on the western fringe of the region. The West Kootenay, once noted for the exceptional quality of its sweet cherries, has been eliminated from commercial production, and in Creston Valley the volume of marketable fruit has been seriously reduced. Few, if any, other virus diseases of tree fruits have demonstrated such rapid and systematic spread from a single, known, infected orchard. Yet there has been no explanation for the infection of that source orchard until recently when evidence was obtained that flowering cherry acts as a latent host of little-cherry virus.

Oriental flowering cherries are grown as ornamentals in nearly all temperate regions of North America, most of them introduced from Japan. The species generally propagated is *Prunus serrulata*. Varieties within this species, and in several other species, are seen in public parks, on boulevards, and in private gardens. Large numbers of trees are produced each year by nurseries on this continent. Substantial numbers are imported from nurseries in Europe, and from Japan.

In 1955, workers in Washington and Oregon reported that a virus carried without symptoms in Japanese flowering cherry is capable of causing small-fruit symptoms when introduced into sweet cherry trees. The first records of the virus were in the *P. serrulata* varieties Shiro-fugen and Kwanzan.

There are several virus diseases that cause small-fruit symptoms in sweet cherry. One is the little-cherry disease that occurs only in the Kootenays. Another is X-disease found in most western United States and Canadian cherry-growing districts. As soon as the virus was discovered in flowering cherry,

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we tried to determine its relationship to the viruses of little-cherry disease and X-disease.

Our investigations in British Columbia, along with those in the United States, have shown that the virus of X-disease causes symptoms in peach and native choke cherry; that it causes small-fruit symptoms in cherry on mazzard rootstocks, but tree-decline symptoms in trees grown on mahaleb rootstocks. The rate of spread through an infected cherry tree is usually very slow.

At Creston, B.C. we found that the virus of the little-cherry disease causes symptoms only in sweet and sour cherry, that peach and choke cherry are immune, that there is invariably spread of the virus throughout a tree within two years, and that cherry trees on mahaleb rootstocks produce small-fruit symptoms comparable to those produced by trees on mazzard rootstocks.

E. L. Reeves, of the United States Department of Agriculture, and co-workers in Wenatchee, Wash., were able to proceed independently with comparisons of X-disease and the disease caused by the flowering cherry virus. We initiated co-operative studies at Creston with those in Wenatchee to provide comparisons of the newly discovered virus with the virus of little-cherry disease.

At Creston we introduced two viruses into the same range of stone fruits, including the most significant indicators of the little-cherry disease. At Wenatchee the virus from flowering cherry only was introduced into comparable trees of all the same hosts.

The combined results of these tests have shown that the flowering cherry virus produces fruit symptoms that are identical to those of the little-cherry disease in Bing, Lambert, and Star cherry, and identical leaf symptoms in Bing, Van, Sam, and Star cherry. The rates of spread through cherry trees are identical. Peach and choke cherry are immune. Cherry trees on mahaleb rootstocks produce fruit symptoms only. Final proof of the identity of two viruses is difficult to obtain, but it can be stated that by all available means of testing, the virus in flowering cherry and the little-cherry virus act in exactly the same manner, whereas the X-disease virus differs from them in many respects.

Within the distribution range of the little-cherry disease in the Kootenays only a few flowering cherry trees have survived recent cold winters. However, a survey has shown that a few trees are thriving in sheltered locations, and these trees have been indexed. The survey disclosed that a surviving planting of trees approximately 30 years old is growing within five miles of the orchard in which the little-cherry disease was first reported in sweet cherry 27 years ago. Indexing on sweet cherry has shown that the three *P. serrulata* trees in this planting now carry the little-cherry virus. There can be no certainty that these infected flowering cherry trees provided the source for the disease outbreak, because they have had a number of years in which they have been exposed to infection from neighbouring sweet cherry trees. However, as they were planted before the little-cherry disease appeared nearby in sweet cherry, and as most of the trees of *P. serrulata* elsewhere carry the virus, including those first imported to North America, there is strong suspicion that these flowering cherry trees introduced the virus to the Kootenays.

It seems probable that in other areas infection of sweet cherry trees can originate from flowering cherry plantings. Over 50 per cent of the clones of *P. serrulata* varieties indexed in Washington and British Columbia have been shown already to carry the virus. Moreover, the virus has been found in some varieties of other flowering cherry species. Final assessment of the remaining varieties and clones must await further readings on test trees in subsequent seasons. The clones carrying the virus have come from all temperate regions of this continent. They include also trees sampled from imported shipments.

There is considerable circumstantial evidence to suggest that the virus rarely spreads from flowering cherry to sweet cherry. Flowering cherry trees have been growing in the vicinity of sweet cherry orchards for a number of years in many locations without apparent spread. However, in 1959, U.S. workers reported an instance in which a number of sweet cherry trees in an experimental plot adjacent to flowering cherry trees became infected with the little-cherry disease, apparently by natural spread. There is a serious danger of introduction of the virus to sweet cherry, when nurseries re-bud rootstocks on which flowering cherry buds have failed. There have been several reports that the disease spreads once the virus has been transferred from flowering cherry to sweet cherry.

A flowering cherry tree in a Kootenay garden, apparently healthy but carrying the little-cherry virus.

Since the little-cherry disease outbreak occurred in the Kootenays, much has been learned about the nature of the disease, its host range, its vectors, and methods that can be used to expedite indexing for its presence in non-bearing trees. This information provides regulatory personnel with measures that can be implemented when new outbreaks occur. These measures would include the quarantining of infected districts, removal of diseased trees, regulation of the movement of fresh fruits and containers, and application of insecticides throughout the affected and the menaced orchards, to reduce populations of leafhoppers that are known to carry the virus. Such a program should effectively retard the spread of the disease. However, no one who has had experience with the ravages of the little-cherry disease relishes the necessity to test these preventive measures in another outbreak.

The showy bloom that has made flowering cherry a popular, widely planted ornamental tree.

The status of the virus in flowering cherry is being explored further. The search is continuing in British Columbia and in Washington State for flowering cherry clones that are free from the virus, and that therefore can be recommended to nurseries as substitutes for the infected clones now being propagated. Attempts are being made to eliminate the virus from infected clones by means of various types of heat treatment. In continuing this investigation, the author will be in Japan this summer surveying sweet cherry plantings for virus occurrence, initiating indexing tests designed to identify virus-free flowering cherry materials, and searching for sweet cherry materials that possess resistance to the little-cherry virus.

Until virus-free clones of flowering cherries are available for planting, there is strong justification for the isolation of cherry orchards and cherry nursery stock from all plantings of flowering cherry trees.

Nickel Salts Show Promise in Grain Rust Control . . . *(from page 9)*

stem rust and leaf rust of wheat. The most effective materials were complex organic compounds containing nickel. Our pathologists followed up the leads obtained in their co-operative studies and proved that simple, inorganic salts of nickel were extremely effective as rust eradicants, even when applied in quantities as low as one pound per acre, only once or twice a season. Moreover the application could be made *after* rust devēlopment had started.

Field tests in 1957, 1958, and 1959 showed that nickel salts were less effective against stem rust than against the less destructive leaf rust. It was shown, too, that in a bad rust year it might be necessary to spray three or four times, at about 7-day intervals, instead of once or twice as originally hoped. The net returns from use of nickel sprays are good, however. In a bad rust year spraying might mean the difference between no crop at all and a reasonably good crop.

Nickel chloride was the first of the simple nickel salts to show exciting promise. Later studies have indicated that nickel sulphate is just as effective and is less likely to damage wheat plants. Because it is manufactured in Canada, nickel sulphate is also cheaper than the chloride, or the less efficient nickel nitrate. At present, nickel sulphate is worth about 40 cents a pound. If it were produced on a larger scale, the cost would probably go down. Although several million pounds would have to be available at strategic points in Manitoba and eastern Saskatchewan, the chemical can be stored for a long time without deteriorating.

Nickel salts may not prove to be the chemicals which will be used to control wheat rust if dangerous new races become widespread before resistant varieties can be released. The demonstration of the value of nickel salts for rust control *is* a significant break-through in the continuing battle against the enemies of efficient and economic crop production in Western Canada. If we can win enough such battles, we may eventually win the war against hunger in the world.

The Role of Fungi in Pest Control . . . *(from page 13)*

and maintenance of a number of them. It has been reported from the University of California that a heat treatment stimulated germination of resting spores of *E. virulenta*. This is the first indication that these spores may be brought to germination when needed, without the lengthy time interval suggested by earlier workers.

At the Insect Pathology Research Institute, Sault Ste. Marie, nutritional experiments are in progress to determine why media containing natural material such as tryptone, liver extract, and yeast extract, are superior to simple, chemically defined media for the growth of *Hirsutella gigantea* isolated from spruce budworm larvae. These studies include the testing of a wide assortment of carbohydrates, various amino acids singly and in combination, vitamins, nucleic acid derivatives, fats, and minerals.

Success in this endeavour to cultivate satisfactorily the more fastidious forms on artificial media will ensure a ready and abundant supply of the organism in all stages of development for further laboratory studies and field applications.